87. The solubility product of $BaCl_2$ is 3.2×10^{-9}. What will be its solubility in mol L^{-1}?

(a) 4×10^{-3} (b) 3.2×10^{-9}
(c) 1×10^{-3} (d) 1×10^{-9}

88. Solubility of CaF_2 is 0.5×10^{-4} mol L^{-1}. The value of K_{sp} for the salt is

(a) 5×10^{-12} (b) 2.5×10^{-16}
(c) 1×10^{-13} (d) 5×10^{-13}

89. Match the column I with column II and mark the appropriate choice.

Column I		Column II	
(A)	$Fe(OH)_3$	(i)	$K_{sp} = s^2$
(B)	Ag_2CrO_4	(ii)	$K_{sp} = 27s^4$
(C)	CH_3COOAg	(iii)	$K_{sp} = 108s^5$
(D)	$Ca_3(PO_4)_2$	(iv)	$K_{sp} = 4s^3$

(a) (A) → (iii), (B) → (ii), (C) → (iv), (D) → (i)
(b) (A) → (ii), (B) → (iv), (C) → (i), (D) → (iii)
(c) (A) → (i), (B) → (iii), (C) → (ii), (D) → (iv)
(d) (A) → (iv), (B) → (i), (C) → (iii), (D) → (ii)

94. (d): $AgCl \rightleftharpoons Ag^+ + Cl^-$

$\quad\quad\quad\quad\quad\quad s \quad\quad s$

$s^2 = 1.5625 \times 10^{-10}$

$s = 1.25 \times 10^{-5}$ mol L^{-1}

Solubility in g L^{-1} = Molar mass $\times s$

$= 143.5 \times 1.25 \times 10^{-5} = 1.79 \times 10^{-3}$ g L^{-1}

90. Solubility product of radium sulphate is 4×10^{-11}. What will be the solubility of Ra^{2+} in 0.10 M Na_2SO_4?

(a) 4×10^{-10} M (b) 2×10^{-5} M

(c) 4×10^{-5} M (d) 2×10^{-10} M

91. The concentration of Ag^+ in a saturated solution of Ag_2CrO_4 at 20 °C is 1.5×10^{-4} mol L^{-1}. The solubility product of Ag_2CrO_4 at 20 °C is

(a) 1.687×10^{-12} (b) 1.75×10^{-10}

(c) 3.0×10^{-8} (d) 4.5×10^{-10}

(c) $4 \times 10^{[illegible]}$ M

94. The solubility product of AgCl is 1.5625×10^{-10} at 25 °C. Its solubility in grams per litre will be

(a) 143.5

(b) 108

(c) 1.57×10^{-8}

(d) 1.79×10^{-3}

Example 92.

The solubility of silver chloride (AgCl) in water at 25°C is 1.06×10^{-5} mol L^{-1}. Calculate the solubility product of AgCl at this temperature.

Solution: The solubility equilibrium of AgCl is :

$$AgCl(s) \rightleftharpoons Ag^+(aq) + Cl^-(aq)$$

One mole of AgCl in solution gives 1 mole of Ag^+ ions and 1 mole of Cl^- ions. Since the solubility of AgCl is 1.06×10^{-5} mol L^{-1}, it will give 1.06×10^{-5} mol L^{-1} of Ag^+ ions and 1.06×10^{-5} mol L^{-1} of Cl^- ions. Therefore,

$$[Ag^+] = 1.06 \times 10^{-5} \text{ mol } L^{-1}, [Cl^-] = 1.06 \times 10^{-5} \text{ mol } L^{-1}$$

Now,

$$K_{sp} = [Ag^+][Cl^-]$$
$$= (1.06 \times 10^{-5}) \times (1.06 \times 10^{-5})$$
$$= \mathbf{1.12 \times 10^{-10}}$$

Example 93.

The solubility of SrF_2 in water is 1.2×10^{-2} g L^{-1}. Calculate the solubility product of the salt at room temperature (molecular mass of SrF_2 = 125.6).

Solution: The solubility equilibrium is :

$$SrF_2(s) \rightleftharpoons Sr^{2+}(aq) + 2F^-(aq)$$

Solubility of SrF_2 = 1.2×10^{-2} g L^{-1}

$$\text{Molar solubility of } SrF_2 = \frac{1.2 \times 10^{-2}}{125.6} = 9.55 \times 10^{-5} \text{ mol } L^{-1}$$

According to above equation, one mole of SrF_2 produces one mole of Sr^{2+} ions and two moles of F^- ions. Therefore,

$$[Sr^{2+}] = 9.55 \times 10^{-5} \text{ mol } L^{-1}$$
$$[F^-] = 2 \times 9.55 \times 10^{-5} = 19.1 \times 10^{-5} \text{ mol } L^{-1}$$
$$K_{sp} = [Sr^{2+}][F^-]^2$$
$$= (9.55 \times 10^{-5}) \times (19.1 \times 10^{-5})^2$$
$$= \mathbf{3.48 \times 10^{-12}}$$

Solution: $BaCl_2$ dissociates ompletely as :

$$BaCl_2 \rightleftharpoons Ba^{2+} + 2Cl^-$$

Conc. of Ba^{2+} in 0.05 M $BaCl_2$ solution is

$$[Ba^{2+}] = 0.05 \text{ M}$$

Let solubility of $BaSO_4$ is 0.05 M $BaCl_2$ solution be x mol L^{-1}.

Then

$$BaSO_4 \rightleftharpoons Ba^{2+} + SO_4^{2-}$$

$$[Ba^{2+}] = x \text{ mol } L^{-1}, [SO_4^{2-}] = x \text{ mol } L^{-1}$$

$$\text{Total } [Ba^{2+}] = 0.05 + x \approx 0.05 \text{ M}$$

($\because$ x is very small)

$$K_{sp} = [Ba^{2+}][SO_4^{2-}]$$

$$= (0.05) \times x$$

or

$$0.05\,x = 1.1 \times 10^{-10}$$

$$x = \frac{1.1 \times 10^{-10}}{0.05}$$

$$= \mathbf{2.2 \times 10^{-9} \text{ mol } L^{-1}}.$$

Example 102.

Calculate the solubility of barium sulphate in 0.05 M barium chloride solution. K_{sp} *of* $BaSO_4$ $= 1.1 \times 10^{-10}$. **N.C.E.R.T.**

SOLVED EXAMPLES

Example 94.

The solubility product of silver bromide is 3.3×10^{-13}. Calculate its solubility.

Solution: The solubility equilibrium is :

$$AgBr(s) \rightleftharpoons Ag^+(aq) + Br^-(aq)$$

Thus, $K_{sp} = [Ag^+][Br^-]$

Let the solubility of AgBr be s mol L^{-1}, then s moles of AgBr dissolved will give s moles of Ag^+ and s moles of Br^- ions. That is

$$[Ag^+] = s, [Br^-] = s$$

$$\therefore \quad K_{sp} = [Ag^+][Br^-] = s \times s$$

$$\text{or} \quad 3.3 \times 10^{-13} = s^2$$

$$\text{or} \quad s = \sqrt{3.3 \times 10^{-13}} = \sqrt{33 \times 10^{-14}}$$

$$= \sqrt{33} \times 10^{-7} = \mathbf{5.74 \times 10^{-7}\ mol\ L^{-1}}$$

Example 95.

Calculate the solubility of $PbCl_2$ if its solubility product is 1.0×10^{-6} at 298 K.

Solution: The solubility equilibrium is :

$$PbCl_2(s) \rightleftharpoons Pb^{2+}(aq) + 2Cl^-(aq)$$

Suppose the solubility of $PbCl_2$ is s moles per litre. Then the concentrations of various species at equilibrium are :

$$[Pb^{2+}] = s, [Cl^-] = 2s$$

$$\text{Now,} \quad K_{sp} = [Pb^{2+}][Cl^-]^2$$

$$1.0 \times 10^{-6} = (s) \times (2s)^2$$

$$1.0 \times 10^{-6} = 4s^3$$

$$\text{or} \quad s^3 = \frac{1.0 \times 10^{-6}}{4}$$

$$\text{or} \quad s = 6.3 \times 10^{-3}\ mol\ L^{-1}$$

Thus, solubility of $PbCl_2$ = **6.3×10^{-3} mol L^{-1}**

90. **(a)** : $RaSO_4 \rightleftharpoons Ra^{2+} + SO_4^{2-}$

$K_{sp} = [Ra^{2+}]\,[SO_4^{2-}]$

Concentration of SO_4^{2-} from $Na_2SO_4 = 0.10$ M

$$Ra^{2+} = \frac{4\times10^{-11}}{0.10} = 4\times10^{-10}\,M$$

91. **(a)** : $Ag_2CrO_4 \rightleftharpoons 2Ag^+ + CrO_4^{2-}$

$Ag^+ = 1.5 \times 10^{-4}$ M

$CrO_4^{2-} = 0.75 \times 10^{-4}$ M $(\frac{1}{2}$ of $Ag^+)$

$K_{sp} = (1.5 \times 10^{-4})^2 \times (0.75 \times 10^{-4}) = 1.687 \times 10^{-12}$

87. **(c)** : $BaCl_2 \rightleftharpoons Ba^{2+} + 2Cl^-$

$K_{sp} = [Ba^{2+}][Cl^-]^2 = x \times (2x)^2 = 4x^3$

$4x^3 = 3.2 \times 10^{-9}$

$\Rightarrow x = 9.28 \times 10^{-4} = 0.928 \times 10^{-3} \approx 1 \times 10^{-3}$

88. **(d)**: $CaF_2 \rightleftharpoons Ca^{2+} + 2F^-$

Solubility (conc): 0.5×10^{-4} $(2 \times 0.5 \times 10^{-4})^2$

$K_{sp} = 0.5 \times 10^{-4} \times 1 \times 10^{-8} = 0.5 \times 10^{-12}$ or 5×10^{-13}

89. **(b)**: (A) : $Fe(OH)_3 \rightleftharpoons Fe^{3+} + 3OH^-$; $K_{sp} = 27s^4$

s $(3s)^3$

(B) : $Ag_2CrO_4 \rightleftharpoons 2Ag^+ + CrO_4^{2-}$; $K_{sp} = 4s^3$

$(2s)^2$ s

(C) : $CH_3COOAg \rightleftharpoons CH_3COO^- + Ag^+$; $K_{sp} = s^2$

s s

(D) : $Ca_3(PO_4)_2 \rightleftharpoons 3Ca^{2+} + 2PO_4^{3-}$; $K_{sp} = 108s^5$

$(3s)^3$ $(2s)^2$